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NASA TECHNICAL MEMORANDUM

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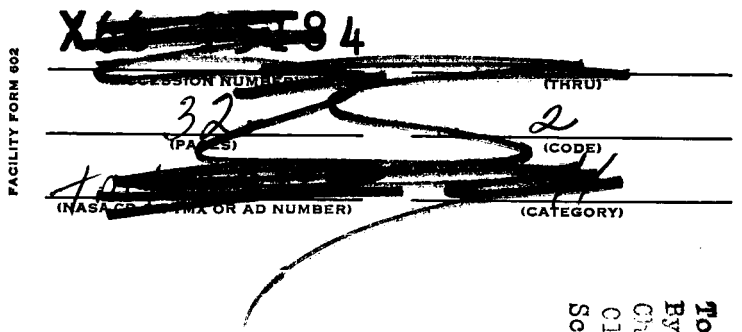

SEMI-ANNUAL PROGRESS REPORT PART III - OSSA PROGRAM SUPPORTING RESEARCH PROJECTS [C]

(JANUARY 1, 1965 TO JULY 1, 1965)

RESEARCH PROJECTS LABORATORY

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

(NASA-TM-X-53392) OSSA PROGRAM SUPPORTING RESEARCH PROJECTS, PART III SEMIANNUAL PROGRESS REPORT, 1 JAN. - 1 JUL. 1965 (NASA) 32 p

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SEMI-ANNUAL PROGRESS REPORT

PART III

OSSA PROGRAM

SUPPORTING RESEARCH PROJECTS

(January 1, 1965 to July 1, 1965)

ABSTRACT

This Progress Report presents the Office of Space Sciences and applications Program of Supporting Research and is Part III of a three part series which describes the George C. Marshall Space Flight Center's Supporting Research Program for the reporting period January 1, 1965 to July 1, 1965.

OSSA studies are submitted in their respective program areas of Lunar and Planetary, Geophysics and Astronomy, Meteorological Systems, Launch Vehicle & Propulsion, 2nd Manned Space Science. Within the framework of Sub-Program and Task Area, both in-house and out-of-house work units convey in condensed form, the purpose, status, accomplishments, problems, and future plans of each study with appropriate illustrations. Finally, an introductory summary gives the highlights of the entire report in reduced form.

Additional copies of this report may be obtained from the MSFC Technical Library, MS-IL.

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SEMI-ANNUAL PROGRESS REPORT

PART III

OSSA PROGRAM

SUPPORTING RESEARCH PROJECTS

(January 1, 1965 to July 1, 1965)

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GROUP 4
Downgraded at 3 year intervals; declassified after 12 years

RESEARCH AND DEVELOPMENT OPERATIONS
RESEARCH PROJECTS LABORATORY

~~CONFIDENTIAL~~

FOREWORD

The George C. Marshall Space Flight Center's Supporting Research Semi-Annual Progress Report was initiated July 1, 1961 in order to facilitate the exchange and dissemination of technical information and research results by providing a qualitative document for the reference of personnel engaged in the promotion of research activities.

This issue, Part I, Part II, and Part III, presents the status of individual work units under the cognizance of the Research Projects Laboratory during the period between January 1, 1965 to July 1, 1965.

This Center is justifiably proud of the effective utilization of research funds as demonstrated by accomplishments such as those found in this issue of the Report.

C. G. Miles, Jr., Chief
Research Program Office

Ernst Stuhlinger, Director
Research Projects Laboratory

ACKNOWLEDGEMENTS

Specific individuals, whose cooperative efforts assisted in the publication of this Report include Mr. Remer and Mr. Ziak and Staff, Management Services Office; Mr. Smith, Quality and Reliability Assurance Laboratory; Mr. W. Murphree and Mr. J. Cauthen, Aero-Astrondynamics Laboratory; Mr. Daussman, Astrionics Laboratory; Mr. Holland, Manufacturing Engineering Laboratory; Mr. Rodman, Propulsion and Vehicle Engineering Laboratory; Mr. Hill and Mr. Barlow, Test Laboratory; Mr. Doherty, Research Projects Laboratory; and Mr. Bean, Computation Laboratory.

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF ILLUSTRATIONS

SEMI-ANNUAL PROGRESS REPORT

PART III

OSSA PROGRAM

SUPPORTING RESEARCH PROJECTS

SUMMARY

This introductory summary is a condensation of some of the material found within the body of this report and is presented as a brief review of progress being reported within the scope of the Office of Space Sciences and Applications Program at this Center. Moreover, OSSA-sponsored work units are submitted in their respective program areas of Lunar and Planetary ATD, Geophysics and Astronomy, Meteorological Systems, Manned Space Sciences, and Launch Vehicle Development.

LUNAR AND PLANETARY PROGRAM

This section of the report is composed of projects associated with planetary quarantine, advanced concepts, and space chemistry.

Planetary Quarantine

Studies dealing with planetary quarantine (sterilization) constitute the major portion of work found in this section. These studies are developing a variety of materials and providing design information for use in connection with the NASA-wide effort to develop heat sterilizable spacecraft for landing on the planets, such as Mars.

Projects relate to the development of sterilizable potting compounds, radomes, and structural elements. One study is underway to determine the steps required in the manufacture and launch of a sterile Mars landing capsule from earliest subassembly operation to the last operation prior to launch. Also, work is in progress to develop, fabricate and test typical Mars landing capsule sterilization containers.

Improved Potting and Encapsulating Compounds

The project, "Development of Improved Potting and Encapsulating Compounds for Space Applications," is continuing toward its objective of developing polymeric materials for embedding electronic modules, and for coating printed circuit boards. Of course, these materials are to be compatible with heat sterilization techniques, and ethylene oxide decontamination procedures. During this period, a previously unreported polymer precursor was synthesized for subsequent conversion to an epoxy-siloxane copolymer. Among

other plans, potted cord wood modules and coated printed boards are to be prepared for testing of coefficient of thermal expansion and other pertinent parameters.

Dielectric Windows and Radome Materials

The study, "Development of Dielectric Windows/Protective Cover Materials for Spacecraft Antenna," is progressing toward the objective of providing a structural protective covering for spacecraft antennas and its mechanisms. Transmission of the antenna signal with a minimum of distortion and attenuation is a factor of prime consideration. The entire system will be compatible with heat sterilization techniques. Silicones, diphenyl oxides, polyimides, and polybenzamidazoles have been selected from screening tests and for further study. Important properties being considered for radome application include electrical properties such as dielectric constant, dielectric loss and temperature dependence of dielectric properties. The dielectric loss is an important electrical property contributing to radome efficiency. Moreover, a vacuum, radiation waveguide dielectrometer was designed and developed. This dielectrometer constitutes an important advance in materials evaluation technique.

Sterilization Studies

The MSFC In-House Study, "Effect of Sterilization Environment on Light Weight Structural Elements" is investigating permanent distortion in various structural shapes and box beam designs. During this period it is reported that permanent distortion from the sterilization cycles can probably be controlled to acceptable limits without strict controls beyond standard manufacturing procedures.

The study, "Development of Manufacturing Procedures for Typical Planetary Spacecraft to be Sterilized by Heating" is an attempt to describe the steps required in the manufacture of a sterile Mars-landing capsule and to document this work in a manufacturing procedures manual. Manufacturing problems being investigated include bioclean facilities, fabrication, assembly, test, handling, packaging, storage, sterilization, transportation, and checkout. At this time, it is reported that the first phase of this work is underway and a decision has been made to develop test hardware for a small atmospheric probe sterilization container.

Advanced Concepts

Study concerning planetary atmospheres is found in the area of study entitled "Advanced Concepts." This effort is providing data on the atmospheres of Venus and Mars for use in advanced studies. Results to date concern the capability of generating parametric values associated with a given atmospheric model.

Space Chemistry

The area of study, "Space Chemistry" consists of a project associated with past water ballast release experiments from the Saturn Vehicle. Moreover, the study, "Investigations of Chemical Kinetics in the Upper Atmosphere" is mainly concerned with the study of photo-chemical dissociation of atmospheric constituents, and the effect of water vapor upon these constituents. Accomplishments reported during this period consist of the design and fabrication of a reaction chamber, beam collimator, capacitor bank power supply and a mirror system for multiple pass absorption studies.

GEOPHYSICS AND ASTRONOMY PROGRAM

Work presented in the Geophysics and Astronomy Program consists of a project which is currently being directed toward the study of ionospheric electron content. This research is involved in the world wide effort to obtain very accurate, long term records of the electron content of the ionosphere through the use of Polar Ionosphere Beacon Satellite (BE-A).

Measurement of Ionospheric Electron Content

The project, "Measurement of Ionospheric Electron Content" has the objective of measuring the number of electrons per square meter in the ionosphere by receiving, recording and analyzing signals from scientific satellites. Progress has involved the establishment of receiving equipment on Green Mountain in the Huntsville area. An additional station to record data from the BE-B satellite, and possibly the Orbiting Geophysical Observatory, was established at the Alabama Agricultural and Mechanical College at Normal, Alabama. Data has been recorded from approximately one hundred passes of the Explorer XXII Satellite. A great deal of effort has been expended in the preliminary interpretation of the records from the Beacon satellite. Presently, efforts are being concentrated on perfecting the data evaluation technique, and processing the recorded and reduced data.

METEOROLOGICAL PROGRAM

This section of the report consists of several projects that are devoted to the development of meteorological systems and the performance of related research.

One of these projects is obtaining wind measurements between $7x10^4$ and $9x10^4$ meters by using the Cajun-Dart system at Cape Kennedy, Florida. It is reported that one firing per week is being carried out under this study.

Other studies are investigating wind and thermodynamic quantities at various altitudes from the surface of the earth to $9x10^4$ meters. These units are resulting in the publication of numerous reports and memorandums which, among other things, describes the launch wind environment for Cape Kennedy.

LAUNCH VEHICLE DEVELOPMENT PROGRAM

Two projects are presented in this section of the report during this period, i.e., "Lower Atmospheric Diffusion Model Study for the Static Vehicle Test Area," and "Study of Wind and Virtual Temperature Profile Prediction."

Lower Atmospheric Diffusion Model Study

This study is formulating optimum atmospheric diffusion and dispersion models which can be used to compute downwind concentrations from large toxic propellant by-product releases into the lower atmosphere. A final report will include the various aspects of the atmospheric diffusion problem.

Wind and Virtual Temperature Profile Prediction

This study is relatively new, and is developing methods for predicting wind and virtual temperature profiles for use with problems associated with sound propagation, flight tests, toxic fuels, vehicle design and mission planning.

MANNED SPACE SCIENCES PROGRAM

Projects presented in this section of the report, at this time, fall under the Apollo Application Program and reflect only these studies under contractual agreement by the close of the current reporting period.

Since these studies have been underway for only a short period, no progress is reported, however, a brief description of purpose and future plans is provided. In general, this work is formulating preliminary designs for geophysical surface and subsurface lunar probes, and an emplaced lunar scientific station. Also, the effects of lunar surface environments on various AAP scientific instruments is being investigated.

PLANETARY QUARANTINE

A. Development of Improved Potting and Encapsulating Compounds for Space Applications

Submitted by
(Technical Supervisor)

W. J. Patterson
R-P&VE-MNP, 876-3834

1. Project Data

Contract Number: NAS8-5499, June 29, 1963-June 30, 1966

Contractor: Hughes Aircraft Company
Culver City, California

2. Purpose of Project. This contract is directed toward the development of polymeric materials sutiable both for embedding electronic modules and for coating printed circuit boards, concurrent with a materials integration effort whereby the polymer systems developed may be selectively modified to meet specific encapsulant requirements. The critical properties of materials developed under this program shall include but not necessarily be limited to dielectric properties, coefficient of linear thermal expansion, low temperature flexibility, and, to a lesser degree, adhesion, transparency, and water absorption. Also, it is desirable that the materials developed not be adversely affected by sterilization techniques, including ethylene oxide decontamination, whereby an environment of 500 ± 50 milligrams ethylene oxide per liter of atmosphere is maintained for 24 hours at 297°K and 35% relative humidity. The potting compounds shall cure readily at temperatures not exceeding 373°K and preferably approaching room temperature; the cured material must be able to withstand the temperature extremes of 218°K-423°K without extensive degradation of its properties. The cure mechanisms and techniques involved in production of the cured product shall be readily adaptable to manufacutring and assembly processes by technicians having little or no experience in plastic technology.

The contractor shall strive to develop encapsulants whose coefficients of linear thermal expansion lie within the range of $25\text{-}50 \times 10^{-8}$ m/m/°K. Conformal coatings shall be developed which exhibit a minimum coefficient of expansion obtainable without the aid of fillers. The high filler/resin ratio necessary to develop encapsulants of the required coefficient of expansion will almost certainly preclude low temperature flexibility but this property shall be inherent in any conformal coatings developed and shall extend to 213°K. The encapsulants developed under this program shall exhibit maximum values of dielectric constant and power factor of 3.0 and 0.01, respectively, measured at 1 kHz. The conformal coatings developed shall exhibit maximum values of dielectric constant and dissipation factor of 4.5 and 0.09, respectively, measured at 1 kHz. All candidate materials shall meet the following specifications for electrical properties: minimum dielectric strength of 10.16 volts per mm (3.215 mm film), minimum volume resistivity of 10^{16} ohm-centimeters at 294°K, a minimum insulation resistance of 10^5 megohm and a minimum surface resistivity of 10^{12} ohms per square centimeter at 294°K. The candidate materials shall exhibit a minimum adhesion of 345,000 N/m^2 to the substrates specified. Water absorption shall not exceed 0.5 percent. The contractor shall strive to incorporate transparency into all conformal coating materials.

3. Technical Status. The synthesis study of epoxy-siloxane copolymers which is oriented toward embedment materials has been directed toward bis (allylphenyl) -siloxanes rather than bis(hydroxyphenyl) -siloxanes in view of the apparent hydrolytic instability of the latter. A new compound, 1,4-bis (allylphenyl) -tetramethyldisiloxane, has been prepared by condensation of p-allylphenylmagnesium bromide with dimethylchloroethoxysilane, followed by hydrolysis to form the necessary disiloxane linkage. The physical data for the compound are as follows:

Boiling Point: 433°K at 266 N/m^2

$n_D^{26} = 1.5196$

Analysis		% C	% H	% Si
	Theory:	71.14	8.14	15.22
	Found:	72.20	8.26	15.35

The next synthesis step is the epoxidation of the terminal allyl groups to form the corresponding bis-epoxide. This monomer may then be polymerized with appropriate curing agents to a solid polymer.

The polymerization of Shell Chemical Company's X-24 difunctional epoxy monomer to a crosslinked, solid material has been carried out using bis(N-methylamino) -diphenylsilane. The resulting high-strength, transparent epoxy-silane polymers exhibited the following electrical data:

	Dielectric Constant (1 kHz)	Dissipation Factor (1 kHz)
Formulation I	3.26	0.0105
Formulation II	3.70	0.0155

These values are significantly lower than those obtained from similar resins which employed m-phenylene diamine as the crosslinking agent.

Synthesis studies of conformal coating-oriented urethane-siloxane copolymers have been conducted in the areas ofpolysiloxane-containing monomer development. Polyurethane materials prepared from aliphatic substituted siloxane glycols confer reasonable chain flexibility but tend to become incompatible as the degree of siloxane contribution increases. This problem has been reduced by introduction of aromatic substitution. It remains to optimize the ratio of aliphatic to aromatic character to produce a material capable of exhibiting good compatibility at significant siloxane contributions. Urethane-siloxane copolymers have been prepared which exhibit a dielectric constant of 3.38 with a dissipation factor of 0.0120.

4. Major Accomplishments. A previously unreported polymer precursor, 1, 4-bis(allylphenyl) - tetramethyldisiloxane, has been synthesized for subsequent conversion to an epoxy-siloxane copolymer. Epoxy-silane copolymers with dielectric constants as low as 3.26 have been developed. Urethane-siloxane copolymers have been synthesized and cured into materials containing 3-4 degrees of polymerization of the siloxane moiety.

5. Problems. Some difficulty has been experienced in epoxidation of 1, 4-bis-(allylphenyl) - tetramethyldisiloxane using m-chloroperbenzoic acid.

6. Future Plans. Synthesis of analogs of 1, 4-bis(allylphenyl) tetramethyldisiloxane will be attempted. These compounds will be designed to allow more ready epoxidation. Potted cord wood modules and coated printed boards are to be prepared for testing of coefficient of thermal expansion and other perinent parameters.

B. Development of Dielectric Windows/Protective Cover Materials for Spacecraft Antenna

Submitted by
(Technical Supervisor)

E. C. McKannan
R-P&VE-ME, 876-1233

1. Project Data

Contract Number: NAS8-11026, June 27, 1963 to November 30,1965

Contractor: Hughes Aircraft Company
Culver City, California

2. Purpose of Project. This contract provides for the development and evaluation of materials for use in radomes and antenna covers on spacecraft. The cover must protect the antenna and its associated mechanism without attenuating the antenna signal. Therefore, the materials must have low dielectric loss properties, high mechanical strength and rigidity, high temperature resistance for sterilization, resistance to launch and planetary atmospheric environments, and low gas permeability. Resistance to the effects of the space environment, compromises, composites, laminates, and coatings will be studied.

3. Technical Status. As reported previously, silicones, diphenyl oxides, polyimides, and polybenzamidazole have been selected from screening tests for further study. Thick section molding into glass laminated 1/2-wave radomes was accomplished even with the more intractable resins. Further, gas transmission and vacuum volatilization were reduced to negligible proportions by suitable processing techniques. Thermal and ultraviolet chemical degradation were reduced to a minimum with the use of a thermal control coating which did not interfere electrically. The major effort has been placed on completion of the dielectrometer. This new instrument measures the dielectric properties of the laminated specimen in an evacuated wave-guide while being heated and exposed to ultraviolet irradiation. Such "in-situ" environmental dielectric measurements represent a major advance in environmental sciences. The apparatus is shown in the attached photograph.

4. Major Accomplishments. Thick section radomes of highly stable and intractable materials have been made and characterized as being capable of maintaining spacecraft antennas in a protected sterilized environment, free of corono, while entering a planetary atmosphere.

5. Problems. None.

6. Future Plans. This contract will not be continued past its present expiration date.

7. Illustrations. Figure 1.1.

C. Effect of Sterilization Environment on Light Weight Structural Elements

Submitted By
(Technical Supervisor)

Ron Crawford
R-P&VE - SAA, 842-3300

1. Project Data

Contract Number: Not Applicable

Contractor: MSFC In-House

2. Purpose of Project. The purpose of this project is to study the effects of sterilization heating cycles on various light-weight structural members, and, if possible, determine guidelines for reducing deleterious effects.

3. Technical Status. Selected sheet-metal structural shapes were formed from various materials. Five light-weight box beams were fabricated from .032 6061-T6 aluminum alloy. These beams differed only in method of joining. Bonding, brazing, spot welding, seam welding and riveting were used. Another riveted truss beam was fabricated form 304 stainless steel. All test articles were subjected to three 60-hour cycles at 423°K. The amount of permanent distortion was measured after each sterilization cycle.

4. Major Accomplishments. The results of this testing indicated that permanent distortion from the sterilization cycles can be controlled to acceptable limits without strict controls beyond standard manufacturing procedures. Where these standard procedures were not followed, tolerances and permanent distortion were excessive.

5. Problems. The most significant problem encountered was determining acceptable methods for making the very sensitive measurements before and after each sterilization cycle.

6. Future Plans. The beam structures will be subjected to a combination of static bending loads and the thermal sterilization cycles to discover any possible deleterious effects. The results of this program will be formally documented with recommendations to assist designers of sterilizable structures.

7. Illustrations. None.

D. Development of Manufacturing Procedures for Typical Planetary Spacecraft to be Sterilized by Heating

Submitted By
(Technical Supervisor)

Ron G. Crawford
R-P&VE-SAA, 842-3300
and
James S. Dickinson
R-ME-MMC, 876-8472
(Alternate Supervisor)

1. Project Data

Contract Number: NAS8-11372 (Phase II), May 5, 1965 to July 5, 1966

Contractor: General Electric Company
Spacecraft Department
King of Prussia, Pa.

2. Purpose of Project. The objectives of this project are to determine and describe, insofar as possible in advance of hard design, the steps that will be taken in the manufacutre and launch of a sterile Mars-landing capsule, from the earliest subassembly operation to the last operation prior to launch. It will identify the differences (from "normal" procedures) that are caused by biological considerations. It will address itself to the general case, to hardware that might typify in size, shape, and complixity, a hypothetical soft-landing capsule that might be used for a Voyager mission. It will describe both recommended procedures and feasible alternatives, giving advantages and disadvantages of each. Recommended procedures for the complete capsule will be outlined, an and detailed procedures will be given for representative subsystems. It will cover precedures for fabrication of subassemblies by vendors; assembly, checkout, packaging, and shipment of the capsule to the launch site; uncrating, insertion of batteries and pyrotechnics, heat sterilization, and sterile insertions (if any); and final checkout, assembly to bus and upper stage, and launch.

The end result of this study will be a Manufacturing Procedures Manual for planetary vehicles which are sterilized. This manual will partially satisfy the immediate "procedure manual" requirements of Section 8, page 4 and Section 5.c(3) of the NASA Management Manual Number 4-4-1.

3. Technical Status. Groundwork for this study was prepared during a previous design and manufacturing study under Contract NAS8-11107, "Guidelines for Typical Planetary Spacecraft to be Sterilized," and in a current design study, "Design Criteria for Typical Planetary Spacecraft to be Sterilized by Heating." The need for this work was affirmed by the OSSA (SL) Sterilization Working Group at its August 1964 meeting. A great deal of preliminary planning has been done both by MSFC and General Electric, and OSSA officials have accepted these plans and the detail work was started near the end of the reporting period.

4. Major Accomplishments. None.

5. Problems. No significant problems which will prohibit or delay the obtaining of the objectives

of this program are anticipated.

6. Future Plans. The contractor will use a complement of flight-type hardware that is surplus from previous contracts. Some of this hardware is from Advent and some from a classified Air Force project which is available at no cost to NASA. This hardware will be examined to determine which of its features would have to be redesigned if sterilization by heat were a requirement. The procedure documents that were used for the original manufacture of this hardware will provide the starting point for development of procedures suitable for a spacecraft that must be kept biologically clean prior to terminal sterilization by heating. These old procedure documents will be modified to add steps to maintain biological cleanliness, extend the procedures to cover the total manufacturing and launch process, and will be upgraded to cover hardware that would simulate, in size, shape, and complexity, a Mars lander.

In addition to, and as a supplement to the preparation of the manufacturing procedures manual, manufacturing personnel will execute a typical spacecraft procurement, fabrication, assembly, test, handling, storage, and sterilization cycle using existing hardware where possible. The assembly sequences will be under controlled conditions specified in NASA Requirements for bioclean facilities.

A study to determine recommendations for vendor requirements and responsibilities for cleanliness, recommended locations for specific sterilization facilities (manufacturing area or launch site), and requirements for selection, training, and supervision of manufacturing personnel will be included in the program.

7. Illustration. Figure 1.2.

E. Development of Typical Mars Landing Capsule Sterilization Containers

Submitted By
(Technical Supervisor)

Ron G. Crawford
R-P&VE-SAA, 842-3300

1. Project Data

Contract Number: NAS8-20502, June 28, 1965 to August 28, 1966

Contractor: Avco Corporation
Research and Advanced
Development Division
Wilmington, Massachusetts

2. Purpose of Project. The primary objectives of this program are two-fold:

a. to develop concepts for typical sterilization containers for various confiturations of planetary landers, and

b. to develop, fabricate and test one sterilization container system for a typical small planetary lander.

3. Technical Status. The earliest phase of study on this program was initiated, and a decision made to develop test hardware for a small atmospheric probe sterilization container.

4. Major Accomplishments. None.

5. Problems. Unknowns surrounding the mircometeoroid flux and effects on various structures are the most important unknowns. A "best guess" criteria will be assumed for study of influence on container development.

6. Future Plans. Concepts will be developed for sterilization containers for the most promising candidates for the first Mars landers. One concept (small spherical atmospheric probe) has been selected for detail design of test hardware. Testing will include: thermal cycles at sterilization qualification temperatures, separation system checkout, pressure-control system checkout, and checkout of devices for increasing connection inside the container. A Marman "V-Bond" type clamp system will be included in the test hardware to test this concept for leakage, strain during sterilization cycles, and separation. Finally the contractor will perform a thorough analysis of all test results with emphasis on obtaining guidelines for submission in "Procedures Manual for Planetary Spacecraft to be Sterilized by Heating, Volume I, Design Guidelines," a manual developed and maintained by Marshall Space Flight Center under a separate contract.

7. Illustrations. None.

ADVANCED CONCEPTS

A. Planetary Atmospheres

Submitted By
(Technical Supervisor)

Robert B. Owen
R-AERO-YS, 876-7763

1. Project Data

Contract Number: Not Applicable

Contractor: MSFC In-House

2. Purpose of Project. The purpose of this study is to provide data on the atmospheres of Venus and Mars for use in advanced studies.

3. Technical Status. A computer program has been established with which values for planetary atmospheric parameters can be obtained. The program yields parameter values as a function of height, and presents results in graphical as well as print-out form.

4. Major Accomplishments. The major accomplishment is the capability to generate the parametric values which result from any particular atmospheric model. The program has been applied to the atmosphere of Venus. A TMX presenting the process and results has been completed. It is entitled "Derivation of Parameter Values for a Greenhouse Model of the Cytherean Atmosphere," and will soon be published.

5. Problems. The major problem is the reconciliation of the wide range of obtained parametric values with the observations of the planetary atmospheres. The fluctuations are caused by uncertainties in the initial conditions which are inserted in the program.

6. Future Plans. As old atmospheric models are modified and new ones proposed, the program will be used to study the implications of the changes. This will result in a more accurate specification of planetary atmospheric environments for use in vehicle design criteria.

7. Illustrations. None.

SPACE CHEMISTRY

A. Investigation of Chemical Kinetics in the Upper Atmosphere

Submitted By
(Technical Supervisor)

S. G. Frary
R-RP-N, 876-8036

1. Project Data

Contract Number: Not Applicable

Contractor: MSFC In-House

2. Purpose of Project. The purpose of this study is to investigate physical-chemical reaction kinetics in the upper atmosphere. Emphasis will be placed upon ght photo-dissociation of water vapor under simulated high altitude conditions.

3. Technical Status. Equipment has been obtained and is being assembled for the studies of the photo-dissociation of water vapor by ultraviolet radiation at low pressures, and the detection and determination of the various atomic, molecular and ionic species obtained. Included are a stainless steel reaction chamber, with a molecular beam collimating system, a vacuum ultraviolet scanning monochrometer, a Bendix time-of-flight mass spectrometer, capacitor bank power supply for ultraviolet flash lamps and associated vacuum systems and electronic control and recording equipment.

4. Major Accomplishments. Major accomplishments are the design and fabrication of the reaction chamber, beam collimator, capacitor bank power supply and the mirror system for multiple pass absorption studies.

5. Problems. The direct connection of the mass spectrometer to the reaction chamber, using a nude source, to permit the detection of short-lived radicals and intermediate is now being studied.

6. Future Plans. Testing and assembly of the equipment is being continued. Relocation of the apparatus in a larger and more convenient area is anticipated this fall. Consideration is being given to the use of recording and simple computational equipment for the collection and evaluation of data obtained. The possibility of obtaining the data in a form suitable for submission to the Computation Laboratory is also being considered.

7. Illustrations. Figure 1.3 shows the reaction kinetics chamber with the residual gas analyzer, a simple cycloidal mass spectrometer at the right and a glass gas handling system on the left. Inserts show the beam collimating system (A) and the helical flash tube mounted in the reaction chamber inside a liquid nitrogen cooled shroud (B).

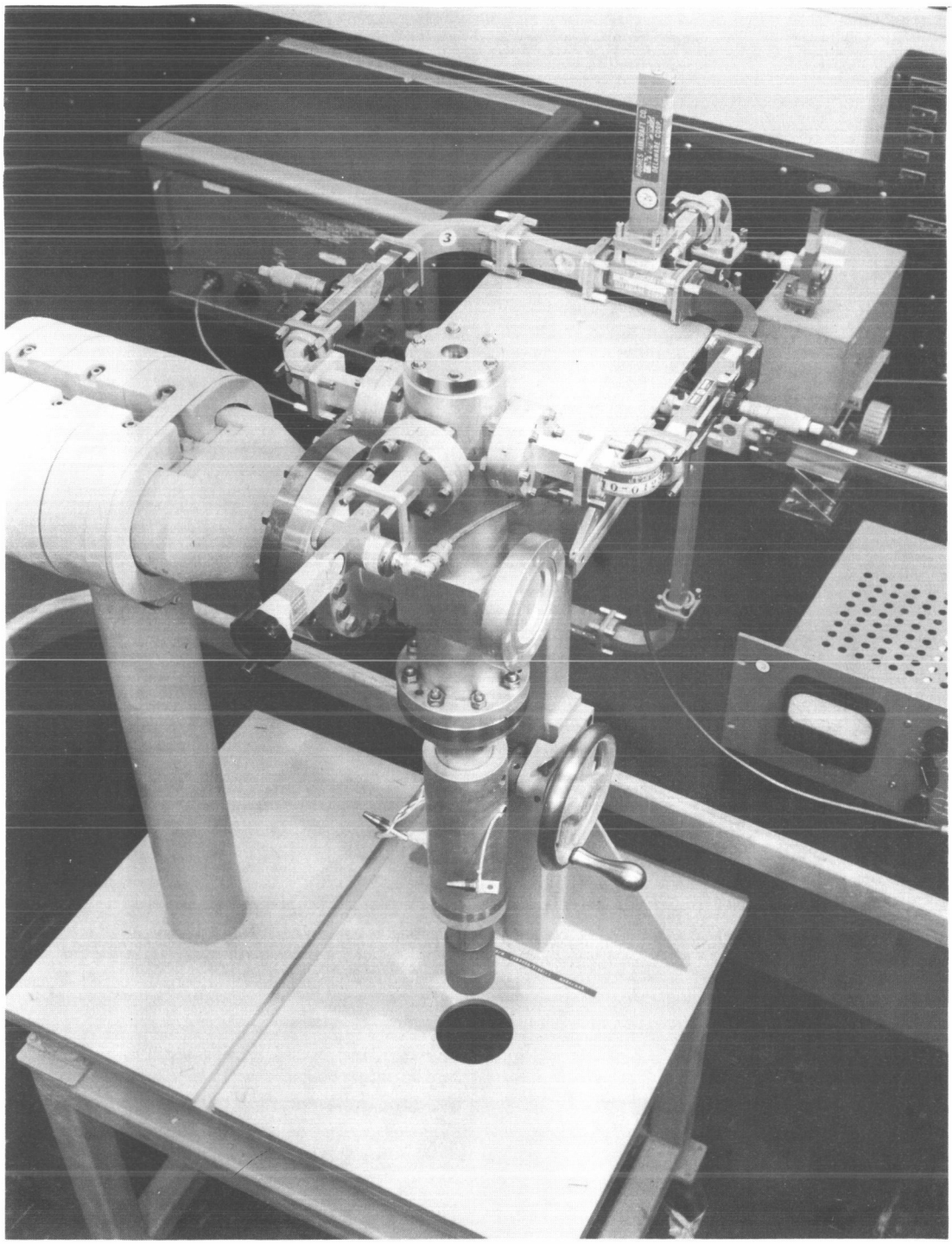

FIGURE 1.1. DIELECTROMETER

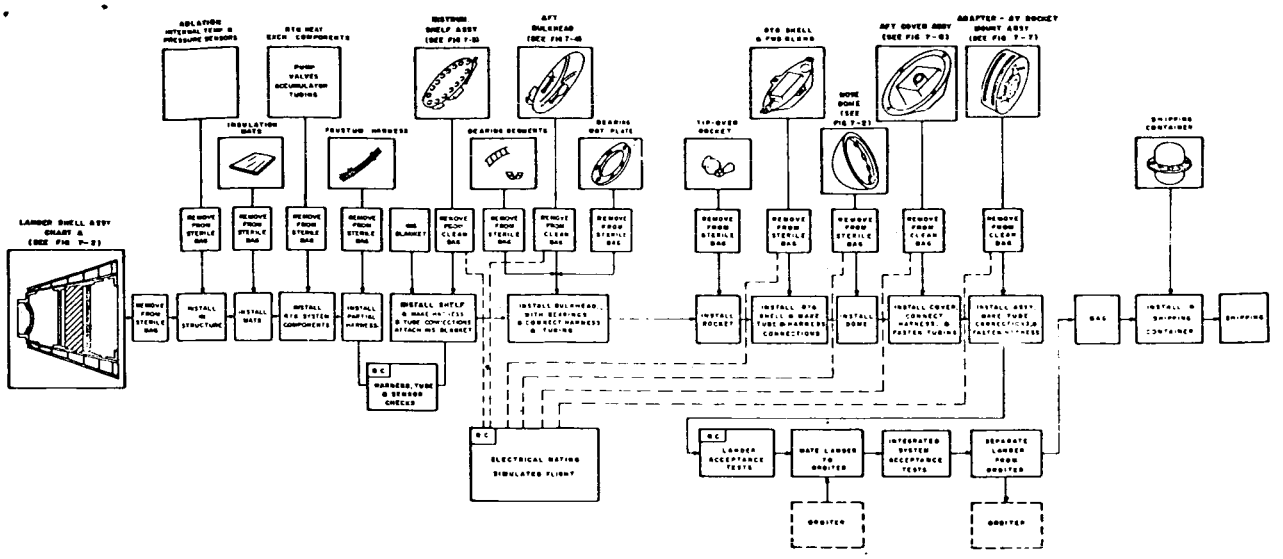

FIGURE 1.2. TYPICAL ASSEMBLY SEQUENCE, PLANETARY LANDER

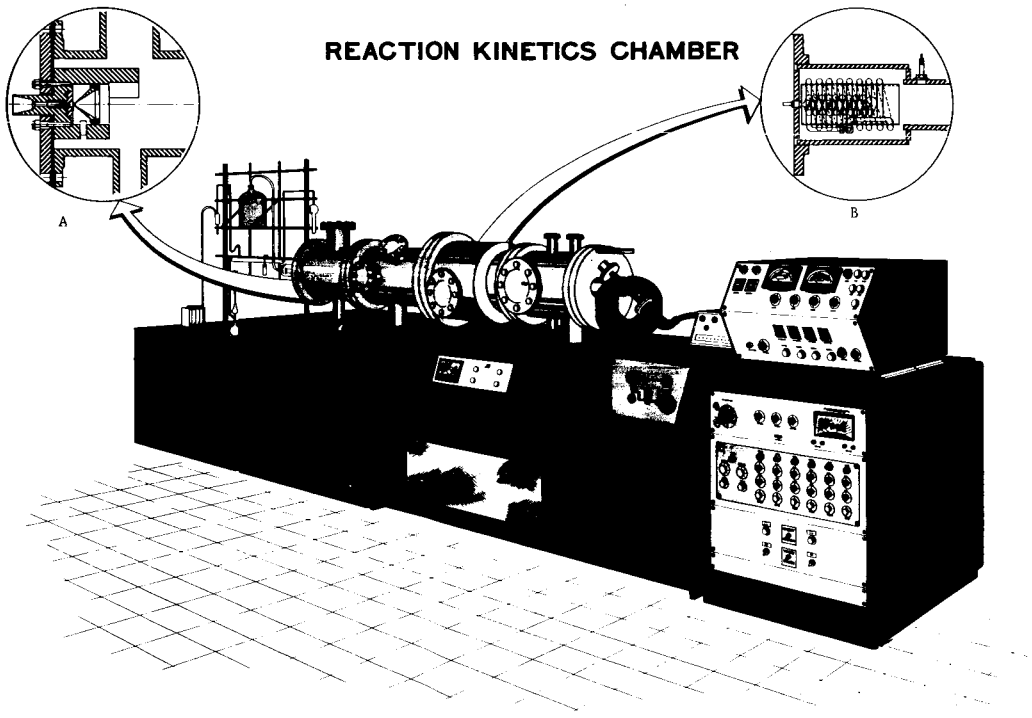

FIGURE 1.3. REACTION KINETICS CHAMBER

IONOSPHERIC AND RADIO PHYSICS

A. Measurement of Ionospheric Electron Content

Submitted By
(Technical Supervisor)

C. R. Baugher
and
E. A. Mechtly
R-RP-S, 876-1141

1. Project Data

Contract Number: NAS8-11365M3, October 17, 1964

Contractor: MSFC In-House and Alabama Agricultural and Mechanical College

2. Purpose of Project. The major objective of this task is the measurement of variation in the electron content of the ionosphere over an extended period. The greatest portion of the data from which these measurements are derived is recorded at MSFC facilities from the Beacon Explorer Satellite. The recorded data is reduced to numerical form by undergraduate students at the Alabama Agricultural and Mechanical College, Normal, Alabama. This college is under contract to MSFC to furnish this service and, in addition, to record a limited amount of data from the satellites at their own facility. Upon completion of this preliminary reduction, the data is returned to MSFC for final evaluation by digital computers.

3. Technical Status. During the reporting period data was recorded each day from the Beacon Explorer - B satellite (Explorer 22) and, after its successful launch, from the Beacon Explorer - C satellite (Explorer 27). On each recorded pass of these satellites five channels of data are received; pass of these satellites five channels of data are received; the Faraday rotation period of the 20, 40, and 41 MHz beacons and the Doppler shift offset of the 20 and 40 MHz beacons. During a typical twenty-four hour period the day time and night time pass with the highest elevation is recorded and, on the occasions when the Beacon Explorer - C satellite passes overhead on three or four consecutive orbits during the transient conditions which exist around sunrise or sunset, several additional passes are recorded.

The recording facilities themselves were unchanged during the reporting period with the exception of the addition of a 360 MHz helical antenna and preamplifier at the MSFC recording station. With this improvement it is now possible for the receiver to remain locked on the satellites' 360 MHz beacons from horizon to horizon when scintillation is not too great.

The work under the college contract proceeded smoothly and at the end of the period the data reduction was virtually abreast of the data recording. It is anticipated at this time that the contract will be extended for an additional year.

4. Major Accomplishments. The actual evaluation of large amounts of data is being delayed until several additional techniques can be evaluated. In addition to the previously developed technique which combines Faraday rotation and dispersive Doppler data to arrive at values of the electron content, a method which depends on the rotation angle difference between the 40 and 41 MHz beacon was programmed and several test cases were examined. The method worked well when applied to data recorded while the satellite was at a high evaluation and the ionosphere contained no horizontal gradients.

5. Problems. The major problem remaining in the analysis of the data is in refining the techniques to the point where they are insensitive to errors caused by ray path splitting and ray path bending. Several promising approaches are being pursued, such as combinations of data which are unaffected by these phenomena.

Toward the end of the reporting period a preliminary investigation was made into the possibility of measuring the rotation of the plane of polarization of the 136 MHz telemetry beacon of the synchronous orbit "Early Bird" satellite. Measurements indicated that the satellite oscillates between five and twenty degrees above the Huntsville horizon at an azimuth south of east. The signal strength of the transmissions was measured to be somewhat less than a -140 dbm at a dipole antenna. The low elevation angle and the low signal level makes it rather doubtful that it will be possible to obtain useful results.

6. Future Plans. At the present efforts are concentrated on perfecting the data evaluation technique, and processing the recorded and reduced data. It is anticipated that this phase of the effort will be well under way at the end of the next reporting period.

At such a time that sufficient data has been recorded and evaluated to draw conclusions about spatial and temporal variations in the electron content of the ionosphere above the geographical area around Huntsville, these results will be formally reported.

7. Illustrations. None.

METEOROLOGICAL SYSTEMS RESEARCH

A. Fabrication and Checkout of a High Altitude Wind Measuring System

Submitted By
(Technical Supervisor)

Robert E. Turner
R-AERO-Y, 876-2767

1. Project Data

Contract Number: NAS8-11624, June 30, 1964 - June 30, 1965

Contractor: Space Data Corporation
Phoenix, Arizona

2. Purpose of Project. The purpose of this study is to furnish the necessary personnel, equipment and materials for fabrication and checkout of a high altitude wind measuring system.

3. Technical Status. Program is being carried out at Cape Kennedy, Florida.

4. Major Accomplishments. Wind measurements between 70-90 km are being obtained at Cape Kennedy, Florida, in support of NASA's space program. Studies and research on high altitude atmospheric conditions are included.

5. Problems. None.

6. Future Plans. To obtain additional wind flow conditions between 80-90 km by using the Cajun-Dart system at Cape Kennedy, Florida. This requires one firing per week.

7. Illustrations. None.

B. Program for Measuring the Structure and Variability of the Upper Atmosphere of the Earth

Submitted By
(Technical Supervisor)

R. E. Smith
R-AERO-YS, 876-7836

1. Project Data

Contract Number: NAS8-20232, June 30, 1965 - June 30, 1966

Contractor: University of Michigan
Ann Arbor, Michigan

2. Purpose of Project. The purpose of this study is to measure the electron temperature and density, the neutral gas temperature, and the density of nitrogen and atomic and molecular oxygen between 100 and 350 kilometers above the earth's surface. These measurements will be used in constructing dynamic models of the upper atmosphere for use in design criteria and related studies in orbital lifetime predictions and aerothermodynamic heating.

3. Technical Status. New contract.

4. Major Accomplishments. There are no main accomplishments to report at this time.

5. Problems. None.

6. Future Plans. Plans are to continue measurement program at same level of effort.

7. Illustrations. None.

C. Wind and Thermodynamic Quantities (Surface to 30 km)

Submitted By
(Technical Supervisor)

Glenn E. Daniels
R-AERO-YT, 876-0917

1. Project Data

Contract Number: Not Applicable

Contractor: In-House

2. Purpose of Project. Special investigations are being made to determine interparameter relationships of atmospheric parameters related to large space vehicle development. This is done to provide information on atmospheric parameters for special studies, design of GSE equipment, or large space vehicle launch or launch restrictions.

3. Technical Status. Various studies have been completed and reports or memorandums prepared on the results.

The following office memorandums were published:

R-AERO-Y-45-65, "Probability of Precipitation Occurring During Saturn Launch," January 5, 1965.

R-AERO-Y-49-65, "Comparison of Surface Wind Design Criteria With Cape Kennedy Wind Statistics," March 10, 1965.

R-AERO-Y-55-65, "Cape Kennedy Annual Wind Component Statistics 0-60 km Altitude, Relative to 72 Degrees Flight Azimuth for Saturn V and Saturn IB Trajectory Dispersion Analysis," March 23, 1965.

R-AERO-Y-59-65, "Comparsion of Surface Wind Design Criteria and Related Total Opaque Cloud Cover Statistics for Cape Kennedy, Florida," April 23,1965.

R-AERO-Y-60-65, "Frequency of Wind Component from the 67 1/2 Degree Azimuth for Range Safety Considerations for SA-8," April 30, 1965.

R-AERO-Y-61-65, "Surface Wind Roses for MSFC," May 7, 1965.

R-AERO-Y-63-65, "Cape Kennedy Surface Quasi-Steady State Wind Statistics, Summary for Design Trade-Off Studies," May 17, 1965.

4. Major Accomplishments. Documentation has been prepared (R-AERO-Y-49-65 and R-AERO-Y-63-65) that defines the design criteria wind statistics such that all researchers use the same data.

5. Problems. None.

6. Future Plans. Studies will continue on other special studies concerned with various interparameter relationships.

7. Illustrations. None.

D. Wind and Thermodynamic Quantities (30 to 90 km)

Submitted By
(Technical Supervisor)

J. W. Smith
R-AERO-YT, 877-3090

1. Project Data

Contract Number: Not Applicable

Contractor: MSFC In-House

2. Purpose of Project. The purpose of this study is to analyze atmospheric data, thermodynamics and wind, in the region between 30 to 90 km to provide better information for use in large space vehicle design and operational studies.

3. Technical Status

a. All available temperature data between 30 and 90 km from rocketsonde observations have been analyzed and a technical paper describing the thermal regime of this area has been written. It is expected that this paper will be published at an early date.

b. All available wind data from rocketsonde observations between 30 and 90 km have been analyzed and a TMX has been written which describes the launch wind environment for Cape Kennedy. This will be published at an early date.

4. Major Accomplishments. Refer to Technical Status for accomplishments reported at this time.

5. Problems. None.

6. Future Plans. Measurement techniques for altitudes above 60 km are still inadequate. The geographical distribution of rockets and observations is inadequate and the quantity of data is so limited that it is impossible to complete a satisfactory climatic analysis of the stratosphere and mesosphere at this time. Due to the high cost and political problems, it will be many years before a more detailed study of the region above 30 km becomes practical. As more rocket sounding data are obtained, the TMX describing the launch environment will be revised.

7. Illustrations. None.

ENVIRONMENT CRITERIA

A. Lower Atmospheric Diffusion Model Study for the Static Vehicle Test Area

Submitted By
(Technical Supervisor)

John W. Kaufman
R-AERO-YE, 876-6392

1. Project Data

Contract Number:	NAS8-11450, June 29, 1964 - March 2, 1966
Modification 1	June 29, 1964 - January 31, 1965 (no cost extension)
Modification 2	June 29, 1964 - March 1, 1965 (Extension was due due to change in scope).
Modification 3	March 2, 1965 - March 2, 1966 (Extension was due to change in scope).

Contractor: The Travelers Research Center, Inc.
Hartford, Connecticut

2. Purpose of Project. The purpose of this study is to formulate optimum atmospheric diffusion and dispersion models which can be used to compute downwind concentrations from large toxic propellant by-product releases into the lower atmosphere. In particular, consideration is given to FLOX by-product releases into the atmosphere which could result from spills, line leaks, conflagration of vehicles or normal exhaust materials released during static firings or during launches. Estimations of source terms are being reviewed for several vehicle test firings and for various atmospheric stability conditions. A final report will include all aspects of the atmospheric diffusion problems, including information on buoyant rise of hot gases, entrainment of air into hot cloud during cloud ascent, stratification of cloud, maximum integrated downwind and peak dosages, etc.

3. Technical Status. A thorough research survey of atmospheric diffusion principles, especially for large contaminant releases into the lower atmosphere, has availed mathematical expressions most descriptive for determining downwind concentrations from instantaneous or continuous pollutant releases. Such mathematical models have been programmed by the contractor and dosage estimates have been generated for several assumed releases of toxic materials. Special emphasis is being given to the buoyancy terms in these diffusion models as the heat generation problem from FLOX spills, FLOX vehicle conflagrations at launch, etc., is of concern. Also, attention is being given to the most favorable atmospheric conditions in which toxic fuels could be used. This will likely determine the probability for launching vehicles when using FLOX type propellants.

4. Major Accomplishments. Mathematical diffusion models have been selected and these have been employed to determine downwind concentrations from large contaminant releases into the lower atmosphere. Major problem areas have been identified, whereas investigations are underway to solve such problems as source term definition, heat generation from FLOX propellant releases, physicochemical properties of FLOX fuel by-products, etc. Field experiments procedures have been designated for proper sampling of downwind concentrations of FLOX by-products contaminants as such estimates will be needed for diffusion model verification. This and additional information are now available in final report form as prepared by the contractor.

5. Problems. The major problem areas in the atmospheric diffusion model specification associated with static firings or launch of vehicles using toxic propellants are as follows: (1) inadequate source term definition, (2) inaccuracies in estimating height of rise of hot clouds from large spills or vehicle conflagration, and (3) lack of information on downwind concentrations as must be determined from actual field diffusion experiments.

6. Future Plans. In the event FLOX type propellants are to be used for static vehicle tests or launches, the problems as outlined above would have to be investigated.

A final report on "Preliminary Estimates of Environmental Exposure for Fuel and Exhaust Products," as prepared by the Travelers Research Center, Inc., dated January 1965, is available. Requests for this document can be fulfilled by contacting the Aerospace Environment Office, R-AERO-Y.

7. Illustrations. None.

B. Study of Wind and Virtual Temperature Profile Prediction

Submitted By
(Technical Supervisor)

Orvel E. Smith
R-AERO-YT, 876-7580

1. Project Data

Contract Number: NAS8-20234, June 29, 1965 - December 29, 1965

Contractor: Travelers Research Center, Inc.
250 Constitution Plaza
Hartford 3, Connecticut

2. Purpose of Project. The purpose of this study is to develop better methods for the prediction of the wind and virtual temperature profiles to meet the different operational requirements of NASA Space Development Program. These operations are in junction with static firings of engines relative to far field sound propagations, operations relative to flight tests, potential use of toxic fuels, and vehicle design and mission planning considerations.

3. Technical Status. This is a new contract.

4. Major Accomplishments. None.

5. Problems. None.

6. Future Plans. Plans are to continue this study at the same level of effort.

7. Illustrations. None.

POST APOLLO

A. Environmental Effects on AES Scientific Instruments

Submitted By
(Technical Supervisor)

Herman P. Gierow
R-RP-J, 876-2488

1. Project Data

Contract Number: NAS8-20244, June 30, 1965 - June 29, 1966

Contractor: Hughes Aircraft Company
Space Systems Division
P. O. Box 90919
Los Angeles, California

2. Purpose of Project. The purpose of this investigation is to delineate the effects that lunar surface environments will have on various AES scientific instruments and to establish the design requirements necessary to permit the instruments to perform satisfactorily. The study objectives are to:

a. Define the effects that the lunar and equipment-induced environments will have on AES scientific instruments.

b. Access these effects for the purpose of definite adequate design countermeasures to insure proper instrument operation.

c. Establish methodologies of conducting experimental tests to evaluate specific instrument designs.

3. Technical Status. This study has been underway for a short period of time.

4. Major Accomplishments. There are no major accomplishments reported at this time.

5. Problems. There are no problems reported at this time.

6. Future Plans. Plans are reflected in the purpose of the project.

7. Illustrations. None.

B. Study of Lunar Geophysical Surface and Sub-Surface Probes

Submitted By
(Technical Supervisor)

Dr. O. K. Hudson
R-RP-J, 876-1387

1. Project Data

Contract Number: NAS8-20243, June 30, 1965 to April 30, 1966

Contractor: Electro-Mechanical Research, Inc.
Sarasota, Florida

2. Purpose of Project. The purpose of this investigation is to perform a preliminary design study of a family of instruments for observing specific properties of lunar surface and sub-surface materials. This investigation will provide mock-ups of the scientific instruments to be used for future design integration testing.

3. Technical Status. At the time of this report the work has been in progress for only a few days.

4. Major Accomplishments. There are no major accomplishments to report at this time.

5. Problems. There are no main problems reported at this time.

6. Future Plans. The next reporting period will encompass Phase I, during which appropriate quantities to be measured will be chosen on the basis of desirability and compatibility, and part of Phase II which is devoted preliminary design and appropriate testing.

7. Illustrations. None.

C. Study of Lunar Geophysical Surface and Sub-Surface Probes

Submitted By
(Technical Supervisor)

Dr. O. K. Hudson
R-RP-J, 876-1387

1. Project Data

Contract Number: NAS8-20085, June 28, 1965 to April 28, 1966

Contractor: Texaco Experiment, Inc.
P. O. Box 1-T
Richmond, Virginia 23202

2. Purpose of Project. The purpose of this investigation is to perform a preliminary design study of a family of instruments for observing specific properties of lunar surface and sub-surface materials. This investigation will provide mock-ups of the scientific instruments to be used for future design integration testing.

3. Technical Status. At the time of this report the work has been in progress for only a few days.

4. Major Accomplishments. There are no major accomplishments to report at this time.

5. Problems. There are no problems reported at this time.

6. Future Plans. The next reporting will encompass Phase I, during which appropriate quantities to be measured will be chosen on the basis of desirability and compatibility, and part of Phase II which is devoted to preliminary design and appropriate testing.

7. Illustrations: None.

D. Study of Emplaced Lunar Scientific Station for Apollo Extension Systems

Submitted By
(Technical Supervisor)

Bill J. Duncan
R-RP-J, 876-2488

1. Project Data

Contract Number: NAS8-20245, June 28, 1965 to April 28, 1966

Contractor: Westinghouse Electric Corp.
Baltimore, Maryland

2. Purpose of Project. The intent of the first portion of this effort is to provide a number of conceptual designs - complete with engineering estimates of power, weight, volume, configuration, and other special requirements - for an emplaced scientific station to acquire environmental data on the lunar surface.

The second phase of this contract will consist of performing a preliminary design on the selected concept from Phase A including a detailed description of the individual experiments, packaging and defining the configurations of instrumentation required, with operating procedures and techniques to permit meaningful scientific observation of lunar phenomena; and an integrated systems definition complete with operational procedures and characteristics.

A nonfunctional, full-scale mockup of the selected concept shall be provided for the complete scientific station with its full complement of instruments.

3. Technical Status. Contract was signed effective June 28, 1965 to initiate the program described above. There has been insufficient time since to have obtained any tangible results.

4. Major Accomplishments. There are no major accomplishments reported at this time.

5. Problems. None.

6. Future Plans. Conduct the above described program.

7. Illustrations. None.

SEMI-ANNUAL PROGRESS REPORT

PART III

OSSA PROGRAM

SUPPORTING RESEARCH PROJECTS

(January 1, 1965 to July 1, 1965)

Prepared by

Research Program Office

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense of Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. The compilation of unclassified reports contained in this document has been determined to have an overall classification of CONFIDENTIAL. Individual reports, however, may be removed and used without classifying them.

This document has also been reviewed and approved for technical accuracy.

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Director, Research Projects Laboratory

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MS-I

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MS-T (6)

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R-QUAL-T
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R-QUAL-A
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R-QUAL-R
S. Smith

R-RP-J
J. Downey

R-RP-N
R. Shelton

R-RP-S
B. Duncan

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